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## RESPONSE OF TOADS TO SOUND STIMULI

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THE sense of hearing in frogs has been critically studied by Dr. R. M. Yerkes. He tested the effect of a great variety of sounds upon frogs in their natural habitat and states that "To no sound have I ever seen a motor response given."<sup>1</sup> The sounds ranged in pitch from a low tone in imitation of the bull frog's croak to a shrill whistle, and in loudness from the fall of a pebble to the report of a pistol. He says further,— "One can approach to within a few feet of a green frog or bull frog and make all sorts of noises without causing it to give any signs of uneasiness. Just as soon, however, as a quick movement is made by the observer the animal jumps. I have repeatedly crept up very close to frogs keeping myself screened from them by bushes or trees and made various sounds, but have never succeeded in scaring an animal into a motor response so long as I was invisible. Apparently they depend almost entirely upon vision for the avoidance of dangers. . . . Many observers have told me that frogs could hear the human voice and that slight sounds made by a passer-by would cause them to stop croaking. In no case, however, have such observers been able to assert that the animals were unaffected by visual stimuli at the same time. . . . There is, however, conclusive evidence that the animals hear one another, and the probability is very great that they hear a wide range of sounds to which they give no motor reactions."

In a later study,<sup>2</sup> Dr. Yerkes found experimentally that although

<sup>1</sup> Yerkes, R. M. The instincts, habits and reactions of the frog. *Harvard Psychological Studies*, 1903, vol. 1, pp. 629-630.

<sup>2</sup> Yerkes, R. M. The sense of hearing in frogs. *Journ. of Comp. Neur.*, 1905, vol. 15, pp. 279-304.

frogs gave no motor reaction to various sounds, their response to tactile stimuli accompanied by these sounds was greater than to the tactile stimuli alone. He concludes that sounds varying in pitch from those of 50 to 10,000 vibrations affect the frog. In nature, "the sense of hearing apparently serves rather as a warning sense which modifies reactions to other simultaneous or succeeding stimuli than as a control for definite auditory motor reactions." In the spring months he found that sounds had a marked influence upon both males and females, but during the winter there was "a much diminished sensitiveness to auditory stimuli in both sexes, but especially in the male."

The description of Dr. Yerkes' experiments given by Professor Kirkpatrick, at Chicago University, greatly interested the writer. Having once kept a frog through the winter and often succeeded in making him croak by imitating his call, it seemed probable that motor responses followed certain sounds. On July 1st I had an opportunity of testing the response of toads to the mating call.

In the course of a walk along the shore of Lake Michigan, we came to a shallow pool in the sand just behind a breakwater. The pool was three or four inches deep, six or eight feet wide, and several hundred feet long. In one part of this we found nine pairs of toads, the females laying eggs in long strings upon the bottom of the pool. There were also two or three unpaired males. The males were much smaller than the females and much more active. The females were of great size, their sides being puffed out with eggs. On the sand they were too heavy to hop, and so walked on all fours like a dog. One female had been seized by two males. We separated her from both, and placed them about ten feet apart. One of the males soon uttered a shrill, trilling note,—a penetrating sound that was well sustained for fifteen or twenty seconds. In doing so he puffed out the skin of his under jaw into a dark gray translucent hemisphere of large size, as is the well known habit of toads. The female immediately swam towards him and the two were soon mated.

After this preliminary experiment we made three others. In the first we separated four couples, putting the females on a little island in the middle of the pool and the males into the water about ten feet away. In four or five minutes they were all mated in

response to the calls from the males. The second time, we separated all the couples in sight, nine I think, and placed the females as before, the males a little farther away. The third time, we separated them all, but put the males on the island where the females had been and carried the females at least thirty feet away towards the side where the males had been. In fifteen minutes, in both cases, every female was taken. In the last case one that had at first hopped ten feet in the wrong direction turned completely around in her tracks at the call, and at the next call, started towards the male.

There were many interesting things observed during the experiments. For one thing the males as well as the females responded to the call, which they could locate very accurately. At the beginning of an experiment, as soon as the males were put down they began to scatter in all directions, swimming excitedly about, now this way, now that. When there were twelve unattached males within four or five feet, a call by one of their number would bring the others from all directions, and in a second or two there would be one or two heaps of clasping, fighting, kicking males, squealing like mice, and rolling over and over. Not all the males gave the call—not over four or five individuals—and these were, as far as I could judge, the most sluggish among them. In giving the call there was quite a marked tendency to climb out of the water up on to a scantling on the inner side of the breakwater. The toads were then two inches above the water.

Motion was evidently the stimulus that started the clasping reflex. This was clearly shown on the sand where I saw one male overtake, clasp, and release another male four or five times in succession before the second succeeded in escaping. Each time the motion of the toad in front would start the one behind. A male would release a male almost instantly, but I did not see a single case of a female clasped and released. How they knew the female I could not tell, but they evidently did not recognize one until they had clasped her. The clasping action, as already stated, seemed entirely automatic.

Several of the solitary males that were sounding the call watched the approach of the females, cocking their heads on one side and moving their bodies so as to look down, and if the swimming

impulse of the female had stopped so that she was carried to the male by her inertia, he would make no response until she began again to swim. Provided that the female is motionless a male may remain for several minutes almost touching her, even in the water, without apparently being aware of her presence. I saw the same thing several times in males and females accidentally thrown together during the fighting. In some cases the female, in responding to a call, would swim right by a male approaching from the side, so that neither seemed to recognize the other.

The females are able to locate the exact spot from which a call is issued. In most cases, at the first or second call, they turned so as to face in the general direction from which it came, the effect being most noticeable with eight or nine females on the sand together. Before the call they faced in all directions,—after the call in one, the most sensitive animals moving two or three feet toward the call at once. The effect was much like that of bringing a strong magnet near a lot of small compass needles. At the next, or some succeeding call, a start would be made, the toads swimming vigorously for a few seconds, then floating forward on the surface of the water until their motion was spent. Often when a female started not more than eight or ten feet away from the calling male, its nose would hit the scantling on the inner side of the breakwater just underneath where the male was sitting. I feel sure, though, that this was not because it saw the male. In one case the calling male faced so that he could not see the approach of the female just beneath him. An inch or two at one side was a mated couple. The female, on reaching the spot where the male was, would be attracted by the motions of the couple and swim towards them, only to leave them immediately and swim across the pool to the other side. This was repeated several times in succession. As already stated, when a female had started towards a calling male, she would pay no attention to any males coming towards her from the side. This was so marked that the response appeared purely mechanical.

One peculiar thing I noticed, or fancied I noticed — for it was hard to be sure — was that the response of a toad, either male or female, was much more rapid and vigorous when in a crowd of its kind than by itself. The first five or six females were mated

within as many minutes, but these may have been the more sensitive toads as I had no means of distinguishing one from another.

From these observations I conclude that both male and female toads can hear and locate in space the call of the male; that the response is unintelligent and mechanical; that to the sound of the mating call a motor response is given, which serves to bring the sexes to the same place; that motion is the stimulus which starts the clasping reflex; that neither sex is able to recognize the other without actual contact; that toads do not quickly profit by experience.

In comparing the single set of observations here recorded with the experiments of Dr. Yerkes, it will be noted that toads were employed in the former and frogs in the latter; it is not probable, however, that there is any considerable difference in the acoustic sense of such closely related animals. It will also be noted that the observations were made in the early summer, when, according to Dr. Yerkes, the sensitiveness to sound is at its best. But even so, the response observed was greater than the results obtained by Dr. Yerkes seem to indicate. It is possible that the frog is capable of hearing and responding to the call of its mate but has no response ready for the report of a pistol or the Galton whistle. It would be interesting to make a phonographic record of the male call, try its effect on females, and observe the result of changing its pitch, quality, and character. The call of the male is not a continuous but a throbbing sound. Nerves that are just beginning to be sensitive to sound might well need a slower rate of vibration than that of the sound itself, and this the throbbing would supply. It was easily perceptible to the ear, so I suppose could not have been at the rate of more than fifteen or twenty vibrations to a second. In Dr. Yerkes' experiments the throbbing electric bell produced "the most marked modification of reaction, probably because it consists, like the induced electric shock, of a rapid succession of stimulating changes." He states that "the green frog is stimulated by sounds as low as 50 vibrations per second; no experimental tests were made with lower sounds."

It is possible that the failure in the laboratory to obtain motor reactions to sound was due to the character of the sound or to other features of experimentation; on the other hand my observa-

tions are concerned with a motor response to only one sound, at one season. The toad reacts directly to the vibrations of the mating call transmitted thirty or forty feet through the air.

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## FURTHER NOTES ON THE BEHAVIOR OF GONIONEMUS

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THE following notes upon the response of this jelly-fish, *Gonionemus*, to light supplement those published by the writer in the *Journal of Comparative Neurology and Psychology* in 1906 (Vol. 16, p. 450-456). All the experiments to be described were made in a dark-room to which sunlight was admitted by means of a porte-lumière apparatus. The aquarium was 100 cm. long, 70 cm., wide and 50 cm. deep.

That light has a directly orienting effect on the animal is seen from the following experiment. The light was admitted through the slit, Fig. 1, *a*, and was reflected vertically downward upon the medusa, *b*, as it lay upon the bottom of the aquarium. The light fell upon one side of the medusa only, so that unilateral stimulation was produced. The cylinder of light was 5 cm. in diameter and therefore sufficient to cover one half of the body and the tentacles belonging thereto, even when extended. Owing to the difficulty of determining definitely the reaction when the medusa lay with its apex downward, it was in each case turned over. After one half of the bell had been illuminated for from 5 seconds to three minutes, the reaction occurred. The first movement carried the medusa vertically upward and it was only after it had pulsed three or four times that its path veered from the perpendicular. It might turn towards the light (Fig. 1, *bc*) or away from it (*bd*) or be so indefinite as not to be placed in either of these categories. The results of one hundred trials, upon different individuals in the main, are appended; those marked "indefinite" are the responses where the animal had not moved far enough to become oriented before ceasing to pulsate: —

Towards the light . . . .	9 reactions.
Away from the light . . . .	70 reactions.
Indefinite . . . . .	21 reactions.

The effect of unilateral stimulation on a swimming jelly-fish

was tried. Care was taken to have the impinging ray as nearly as possible parallel to the oral-aboral axis of the animal. When thus illuminated, the medusa changed its course, moving away from the axis of light so that the path formed an acute angle with the ray.

Attention was then directed to the movements of *Gonionemus* when swimming freely in an aquarium illuminated from one direction. Figure 2 explains the arrangement. The sunlight was reflected through the aquarium from side to side (*xy*). A jelly-fish was freed at the point *a*, and it at once sank to the bottom. Within a few seconds it began to swim and finally reached the top of the water. The path, however, was not vertical, but was inclined away from the light as shown by the path *Ab*. On reaching the surface, the ordinary reaction took place whereby it inverted and sank in the vertical line *bB*. The process was repeated so that the resultant of the whole was the direction *Ah*. In this way it will be seen that the medusa ultimately reaches the farthestmost point, as a result of the light acting exactly as in the simpler experiments in unilateral stimulation. In one case, that of a strong swimmer, the path followed was not broken by frequent inversions, inasmuch as the animal did not reach the surface until it had passed to the opposite side of the aquarium, a distance of about 70 cm.

That it is the direction of the ray of light that is the important factor in orientation, is made evident by the following experiment (Fig. 3). It will be seen that the light was thrown upon the aquarium at the angle indicated by the arrow, so that the end *abc*, lying nearer the source of light, is dark, the opposite end being illuminated. When a medusa starts at *b* in the light, it rises to the top and performs the actions just described, so that it reaches ultimately the end *d*. By this means we find an accumulation of jelly-fish in the end farthest from the light. Here they will remain until they die, or, as is often the case, they begin to swim regardless of the direction of the light and ultimately reach the shaded area, in which they settle down as described in my previous paper.

Yerkes<sup>1</sup> has described a very interesting response in *Gonionemus*

<sup>1</sup> Yerkes, R. M. Concerning the Behavior of *Gonionemus*. *Journ. Comp. Neur.*, 1906, vol. 16, p. 457-463.

under unilateral stimulation, a reaction observed many times by the writer. The animal is seen to pull the bell out of the light by means of its tentacles. Careful observation shows that the tentacles within the lighted area are not attached, but lie extended and passive. The bell itself is likewise motionless. The case is different with the portion of the bell and its tentacles lying in the shade, as these parts are generally more or less active. It is very improbable that there is any complex coordination here that

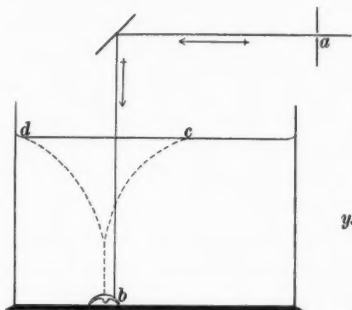


Fig. 1

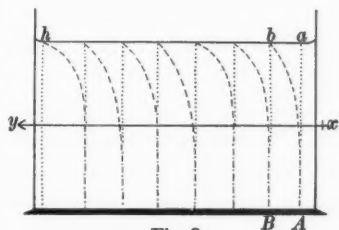


Fig. 2

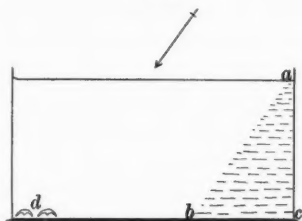


Fig. 3

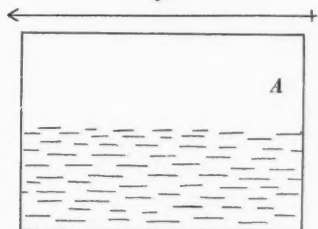


Fig. 4

Figs. 1-4.—Diagrams illustrating the response of *Gonionemus* to light.

serves to move the body away from an area of light. The action seems to be wholly undirected. This interpretation is strengthened by the fact that, in some cases, the body has been drawn directly into the sunlight by those tentacles belonging to the illuminated side, the tentacles themselves being shaded. At other times the tentacles of one side of the body were seen to be carried up over the bell and to become attached to the underlying sand on the opposite side of the jelly-fish, after which the animal turned a

complete somersault by means of the tentacles. At first this was observed in medusae resting in the sunlight; the action was likewise seen in animals in the shade so that it has nothing whatsoever to do with the effect of light.

In the notes previously published, the writer made an attempt to determine the cause of the peculiar behavior of the animal in inverting the bell on reaching the surface of the water. The medusa has no mechanism other than contact whereby it can turn the bell on a transverse axis and thus invert it; it is never observed to turn in its path abruptly. As the equilibrium of the bell is destroyed when the animal reaches the surface and pushes one edge of the bell through the surface film, the inversion occurs. It frequently happens that medusae are found that will not remain mouth down even when so placed by hand. Such individuals kept from inverting pulsate violently for long intervals and come to rest only when they are turned over.

In the paper just cited, the writer interpreted the accumulation of *Gonionemus* in the shade as the result of trial and error. Further work has strengthened this conclusion. Only in the special case where the shadow will be met as the medusa moves away from the source of light, can this be *directly* the result of the orienting factor of light. This is shown in the experiment illustrated by Fig. 4, a view of the aquarium from above. The light is sent lengthwise through the aquarium and parallel with its base. One side is shaded. Individuals freed at *A* in the sunlight, move in their characteristic way to the farther end of the aquarium. Some, moving irregularly, enter the shaded area and remain there. Ultimately, the great majority of the animals are found in this area as described in the previous paper.

Yerkes<sup>1</sup> has described the light reactions of this medusa in the following words,—

"*Gonionemus* always settles down in a shaded region,—in other words, it is negatively photokinetic or photopathic.

When a number of the medusae are placed in a glass vessel before a window they usually collect in the darkest region of the vessel. A simple test of this was made by putting a number of the animals in a dish having a bottom

<sup>1</sup> Yerkes, R. M. A Contribution to the Physiology of the Nervous System of the Medusa *Gonionemus murbachii*. Part I. *Amer. Journ. Phys.*, 1902, vol. 6, p. 446.

16 × 10 inches and a depth of 3½ inches, one-half of which was covered with a black cloth. By way of illustration, the results of one test were as follows: eight animals were put into the dish in the afternoon at four o'clock; within fifteen minutes all were in the light half of the vessel, and there they remained with some changes of position until nine o'clock in the evening. At seven o'clock the next morning only one was in the light region, and of the others several were attached to the sides and bottom of the dark region of the dish. Similar results were gotten with several lots.

Again, when *Gonionemi* in a glass collecting pail are disturbed by agitation of the water, they swim about rapidly and in a few minutes most of them are found on the more intensely illuminated side of the vessel. If, now, they are allowed to remain undisturbed for an hour, they will be found either equally distributed throughout the vessel or collected in the darker region.

There are here two questions to be answered. First, why do the animals at first come to the light? Secondly, why is it that they are later found in the shaded regions? The following statement of the relation of the motor reaction of *Gonionemus* to stimulation by light accounts for the facts. In ordinary daylight they are, *when swimming*, positively phototactic; in very weak light, on the contrary, they are not directed by the stimulus to any considerable degree, and therefore appear to be indifferent. They come to rest in an intensity of light which is below that necessary to direct their movements to any important extent and are therefore negatively photopathic.<sup>2</sup>

In a later paper<sup>2</sup> he described, as follows, a new set of experiments which corroborate his earlier conclusions.

"Eleven medusæ were placed in a white earthenware dish. The dish was illuminated by direct sunlight. After a few seconds, one-half of the dish was covered with a piece of black card-board. Within a minute ten of the eleven medusæ were in the sunlit portion of the dish and there they remained for about two and one-half minutes, swimming about actively but without moving far in any direction. Then as quickly as they had gathered in the sunlit portion they moved to the shaded portion and in less than a minute, all but two were in the shade of the cardboard."

In my former paper (p. 452) I stated that, by the use of a large jar, "33 cm. high and 21 cm. in diameter," no such reaction was observed. I can only add that the experiments conducted during the past summer with the aquarium 100 cm. by 70 cm. by 50 cm. bear out this conclusion. The collecting of the medusæ in the light does not occur where large vessels are used and where reflections from the sides are eliminated. The writer believes that Yerkes' results were modified by the use of a small vessel with

<sup>2</sup> Yerkes, R. M. Concerning the Behavior of *Gonionemus*. *Journ. Comp. Neur.*, 1906, vol. 16, p. 459.

highly reflecting sides. Moreover, it is not clear from Yerkes' text that light of the same intensity was used since some of his experiments were conducted from 4 in the afternoon until 9 at night; at such times the light would be constantly decreasing in intensity. Again, he obtained the reaction by agitating the water, setting the medusae swimming in all directions. Under such conditions it would be very difficult to determine how much the movements of the jelly-fish were due to its own activities and how much to the currents set up by the agitation.

The writer's experiment described above where light was thrown on a swimming medusa shows too, that the reaction to light is the same in an individual swimming as in one at rest, and not different, as Yerkes believes. Inasmuch as experiments conducted under more normal and more carefully arranged conditions do not exhibit the reaction, the writer believes that *Gonionemus* is *at no time* positively phototactic.

These experiments lead, moreover, to the conclusion that the reaction of *Gonionemus* to light is a tropic one, and that the accumulation of the animals in shaded areas is referable to the method of "trial and error."

The thanks of the writer are due to Dr. T. H. Morgan for many suggestions in regard to the work and to the Marine Biological Laboratory for facilities.

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## PLEISTOCENE PLANTS FROM ALABAMA<sup>1</sup>

EDWARD W. BERRY

IN the course of the cooperative study of the Atlantic coastal plain from the Potomac river southward during the past season, plant-bearing beds of Pleistocene age have been discovered at various localities, more particularly in Virginia, North Carolina and Alabama. A rather interesting and highly fossiliferous deposit of this character occurs along the Chattahoochee river in Russell County, Alabama, where the collections upon which the following brief communication is based were made by Dr. L. W. Stephenson of the Federal Survey, who also very kindly furnished the sections here given. The locality is a few hundred yards below Abercrombies Landing on the Alabama side of the Chattahoochee river, and about seven and one-half miles below Columbus, Georgia.

The recognizable leaf-remains have been found at two levels: they occur in an upper layer of hard, dark drab, rather pure clay which dries to an ash color, and in a lower layer of very dark impure peat. The leaf-remains found in the clay are fairly permanent, but those in the peat are very perishable and have been saved and identified by allowing the material to become thoroughly macerated in water and then carefully floating out the larger fragments; from these, sun-prints giving the exact outline are made before the specimens become thoroughly dry. If allowed to become too dry they crumble to powder. After the prints have been made the specimens are mounted on small cards and coated with glue, but even in this condition they are extremely fragile and liable to destruction.

The following two diagrammatical sections were taken about 100 yards apart; No. 1 shows the leaf-bearing horizons, the lower of which is partially concealed by land slips, and No. 2 shows a complete section to the water's edge. From the way in which the base of the exposure is concealed in section No. 1, it is impossible

<sup>1</sup> Published by permission of the Director of the U. S. Geological Survey.

to be certain that the peat is in place in the section and does not represent more recent drift material; however, the opinion of the collector and all of the circumstantial evidence are strongly in favor of the view that it is a true Pleistocene deposit, somewhat older than the overlying beds. The argument for this interpretation may be briefly stated as follows:—The peat which was uncovered over an area two by ten feet had every appearance of forming an integral part of the section. The material itself is very similar to the somewhat more argillaceous material occurring at the same level, and in place, in section No. 2. Seven species have been detected both in the peat and in the overlying clay, the latter unquestionably Pleistocene. These forms are *Quercus virginiana* Mill, *Quercus prinus* Linné, *Quercus nigra* Linné, *Betula nigra* Linné, *Platanus occidentalis* Linné, *Carpinus caroliniana* Walt., and *Ulmus alata* Michx.

The deposits record progressive changes in the conditions of deposition which may be recast somewhat as follows:—The lower gravel bed probably represents material deposited near the mouth of a stream with considerable current, during the brief erosion interval immediately preceding the deposition of the peat. With the subsequent subsidence of the land the lower stream valleys were transformed into estuaries and a barrier beach was built by wave action, which impounded the stream or lagoon, forming a swamp where the peaty material was accumulated. With the continued sinking of the land the advancing shore line spread a mantle of gravel (the upper gravel bed) over the swamp and with the still greater depression of the region, the overlying clays were deposited in quiet estuary waters.

With regard to the exact stage of Pleistocene represented, it is very probable that these Chattahoochee materials are to be correlated with those late Pleistocene beds which have been called the Talbot formation in Maryland and Virginia, and which contain numerous similar swamp deposits. The species of plants represented are all forms which occur in the recent flora of Alabama, although the present range of some of them is considerably different. For example, the northern limit of the live oak is about one hundred miles due south while the southern limit of the chestnut oak is about forty miles due north of Abercrombies Landing.

The willow oak is also rare as far south as this point although it is abundant a few miles to the northward.

The flora as a whole furnishes no evidence of climatic conditions appreciably different from those which exist at the present time in this region, although the grouping of species was quite different from that which obtains along the present Gulf coast.

The presence of *Tsuga canadensis* (Linné) Carr., and *Betula*

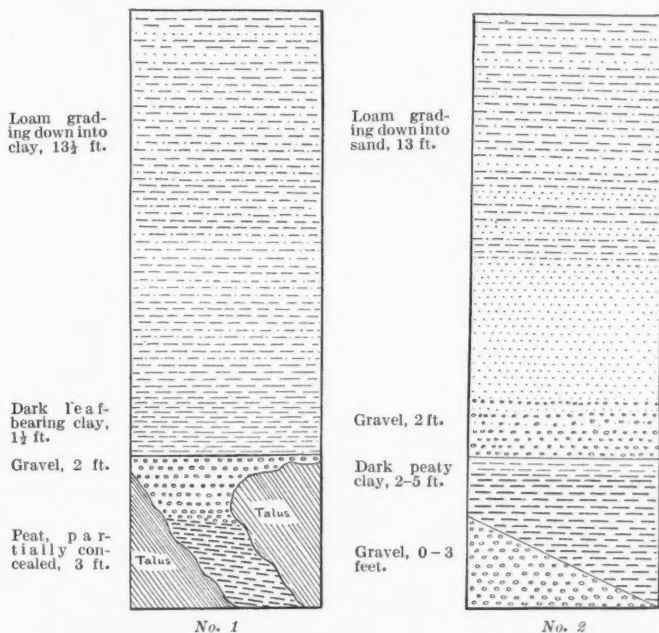


FIG. 1. Pleistocene sections along the Chattahoochee river in Alabama. No. 1 is about three hundred feet north of No. 2.

*lenta* Linné in the existing flora of Alabama at an isolated locality in Winston county, miles south of their usual range, coupled with the presence of the larch in the Pleistocene of Georgia, would seem to indicate cooler conditions at some time in the Pleistocene, presumably at an earlier time than is represented by the fossils from near Abercrombies Landing.

In addition to the species enumerated below, there are a con-

siderable variety of small seeds, husks of *Hicoria*, and the cone scales and needles of *Pinus*, which it has seemed best not to determine positively at the present time. Remains of the cypress (*Taxodium*) and the gum (*Nyssa*) which are usually present in deposits of this age have not been detected.

#### FAGALES

***Carpinus caroliniana*** Walt., *Fl. Car.*, p. 236, 1788.

Pl. 1, Figs. 8, 9.

Berry, *Journ. Geol.*, vol. 15, p. 340, 1907.

A species of low rich woods which ranges from Canada to Florida and Texas and is common throughout Alabama. The fossil leaves are present in both the peat and the overlying clays. Recently recorded by the writer from the Pleistocene of North Carolina.

***Betula nigra*** Linné, *Sp. Pl.*, p. 982, 1753.

Pl. 2, Figs. 2-4.

Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.

Berry, *Journ. Geol.*, vol. 15, p. 341, 1907.

A species which in the modern flora ranges from New England to Texas and which is common throughout Alabama, especially along the stream banks. Several leaves occur in both the peat and the clays and a small fragment of the characteristic bark was also detected in the peat. This species has been previously recorded from the Pleistocene of North Carolina and West Virginia.

***Fagus americana*** Sweet, *Hort. Brit.*, p. 370, 1826.

Pl. 2, Fig. 7.

Berry, *Torreya*, vol. 6, p. 88, 1906; *Journ. Geol.*, vol. 15, p. 341, 1907.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 226, 1906.

***Fagus ferruginea*** Michx., Lesquereux, *Amer. Journ. Sci.*, vol. 27, p. 363, 1859; *Geol. of Tenn.*, p. 427, pl. 7 (K), fig. 11, 1869.

*Fagus ferruginea* Ait., Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.

Mercer, *Journ. Phila. Acad.*, (ii), vol. 11, pp. 277, 281, fig. 8 (15), 1899.

In the modern flora the beech is a prominent element in the mesophile valley forests of the Alleghenian, Carolinian and Louisianian zones. It was also a very prominent Pleistocene type and has been recorded from the Pleistocene of Pennsylvania, Maryland, Virginia, West Virginia, North Carolina and Tennessee. Near Abercrombies Landing it is represented in the peat by four or five of the characteristic husks, two nuts and one imperfect leaf.

*Quercus nigra* Linné, *Sp. Pl.*, p. 995, 1753.

Pl. 1, Figs. 3, 4.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

This species ranges in the Recent from the Louisianian zone northward as far as Delaware and is common throughout Alabama where it inhabits low rich woods and sandy pine-barren swamps. It is by far the most abundant leaf in the peat deposits, possibly due to its ability to resist decay; in the clays a single impression was found, showing the basal two thirds of a leaf. This species has recently been recorded by the writer from the Pleistocene of North Carolina.

*Quercus virginiana* Mill, *Gard. Dict.*, Ed. 8, No. 16, 1768.

Pl. 1, Fig. 2.

The live oak is a tree of the sea-coast, and in Alabama rarely occurs north of latitude 31°. Thus its northern limit in this state is about one hundred miles due south of Abercrombies Landing,—collateral evidence, if such were necessary, that the Pleistocene sea or estuaries of it reached as far north as this point in the late Pleistocene. The species is present in both the peat and in the overlying clays, and so far as I am aware has not previously been recorded in the fossil state.

*Quercus prinus* Linné, *Sp. Pl.*, p. 996, 1753.

Pl. 1, Fig. 5.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

The chestnut oak is a tree of the rocky woods and hillsides and makes its best growth in Alabama on elevations exceeding eight hundred feet. Its present southern limit coincides approximately with the isothermal line of 60° F., which also serves to mark the boundary between the Carolinian and the Louisianian zones. This line crosses the Chattahoochee river near West Point, Ga., or about forty miles due north of Abercrombies Landing. Two leaves were found in the peat, and one fragmentary specimen showing venation but not marginal characters is from the overlying clays. It was recently recorded by the writer from the Pleistocene of North Carolina where it is present in considerable abundance.

*Quercus phellos* Linné, *Sp. Pl.*, p. 994, 1753.

Pl. 1, Fig. 1.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

The willow oak is a common element in the mesophile forests of the northern part of Alabama; it becomes rare, however, south of the long-leaf pine belt which stretches across the central part of the state, its southern boundary crossing the Chattahoochee river just north of Abercrombies Landing. The fossil leaves are a common element in the peat but have not been detected in the overlying clays. It was recently recorded by the writer from the Pleistocene of North Carolina where it is very common.

*Ulmus alata* Michx., *Fl. Am. Bor.*, vol. 1, p. 173, 1803.

Pl. 1, Figs. 6, 7.

Berry, *Journ. Geol.*, vol. 15, p. 343, 1907.

The water elm is common throughout Alabama and ranges northward as far as southern Illinois and Virginia. The Pleistocene material from Abercrombies Landing contained two fragmentary specimens, one from the peat and the other from the overlying clays. These leaves show the characteristic serrated margin of this genus. They are smaller and narrower than the leaves of *Ulmus pseudo-racemosa* Hollick from the Pleistocene of Maryland and the character of the marginal teeth is also somewhat different. The state of preservation indicates that the surface was roughened or somewhat pubescent in life. They are identical with the more perfect leaves which I have referred to this species from

the Pleistocene of North Carolina, and also agree admirably with leaves from the existing tree, so that the identification is reasonably sure in spite of the meager materials.

## RANALES.

**Liriodendron tulipifera** Linné, *Sp. Pl.*, p. 535, 1753.

The tulip tree is a common mesophile type of the Alleghenian, Carolinian and Louisianian zones, its southern limit in Alabama being about latitude 31°. Material from Abercrombies Landing contained two positively identified winged carpels and several more doubtfully determined fragments all of which came from the peat. The genus *Liriodendron*, which has such an extremely interesting geological history,<sup>1</sup> has furnished a large number of American Cretaceous species ranging from the mid-Cretaceous onward, but none have been found in the American Tertiary. In Europe and the Arctic regions, however, a number of Tertiary forms have been described, especially from the Pliocene,—the leaves of *Liriodendron procaccinii* Unger from France and Italy being scarcely distinguishable from those of the existing species. The material from Alabama is, so far as I am aware, the first Pleistocene record of *Liriodendron*, although Schmalhausen records leaves which he has identified as this species from the Altai Mountains of Central Asia in strata which he refers doubtfully to the Pliocene.<sup>2</sup>

## ROSALES.

**Platanus occidentalis** Linné, *Sp. Pl.*, p. 999, 1753.

Pl. 2, Fig. 5.

Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.

Penhallow, *Trans. Roy. Soc. Can.*, (ii), vol. 2, sec. 4, pp. 68, 72, 1896; *Amer. Nat.*, vol. 41, p. 448, 1907.

Mercer, *Journ. Phila. Acad.*, (ii), vol. 11, p. 277, 1899.

Berry, *Journ. Geol.*, vol. 15, p. 344, 1907.

<sup>1</sup> Berry, Notes on the Phylogeny of *Liriodendron*, *Bot. Gaz.*, vol. 34, pp. 44–63, 1902.

<sup>2</sup> Schmalhausen, Ueber tert. Pflanzen aus dem Thale des Flusses Buchtornia am Fusse des Altaigebirges. *Palaeontographica*, vol. 33, 1887.

*Platanus aceroides* Göpp., Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 231, pl. 73, 74, 1906.

In the modern flora this species inhabits low woods and banks from Canada to Florida and Texas. In Alabama it frequents the bottom lands of the central part of the state and is infrequent in the southern part. It is an abundant Pleistocene type and has been previously recorded from Canada, Pennsylvania, Maryland, West Virginia and North Carolina. The Abercrombies Landing remains include the fragment of a central part of a leaf shown in the figure, which has the characteristic venation but none of the marginal characters and which comes from the clays; and a still smaller fragment from the underlying peat which shows one of the marginal points.

#### SAPINDALES.

*Ilex opaca* Ait., *Hort. Kew.*, vol. 1, p. 169, 1789.  
Pl. 2, Fig. 1.

Hollick, *Bull. Torrey Club*, vol. 19, p. 331, 1892.

Berry, *Journ. Geol.*, vol. 15, p. 345, 1907.

The holly frequents damp banks and hammock lands in Alabama and ranges northward to New York and southeastern Massachusetts. It has been recorded by Hollick from the supposed Miocene at Bridgeton, N. J., and by the writer from the North Carolina Pleistocene. A single specimen was found at Abercrombies Landing in the peat.

#### ERICALES.

*Xolisma ligustrina* (Linné) Britton, *Mem. Torrey Club*, vol. 4, p. 135, 1894. Pl. 2, Fig. 6.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 236, pl. 69, fig. 6, 1906.

Berry, *Journ. Geol.*, vol. 15, p. 346, 1907.

In the present Alabama flora the typical forms of this species inhabit the damp banks of small streams in the mountainous portion of the state. It is of a generally more northern distribution, having its southern limit along the southern edge of the metamor-

phic hills in Lee county, and is not a member of the Louisianian flora. In a fossil state it has been previously recorded from Maryland and North Carolina. At Abercrombies Landing it is confined to the peat. *Xolisma foliosiflora* (Michx.) Small which Mohr<sup>1</sup> considers to be only a variety of this species, and which is common in the Alabama coastal plain and on lowlands westward into Louisiana and northward as far as Virginia, is apt to have leathery leaves which are usually distinctly serrulate. It may be considered to be the coastal plain descendant of the more ancient *Xolisma ligustrina*.

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<sup>1</sup> Mohr, *Bull. Torrey Club*, vol. 24, p. 24, 1897.

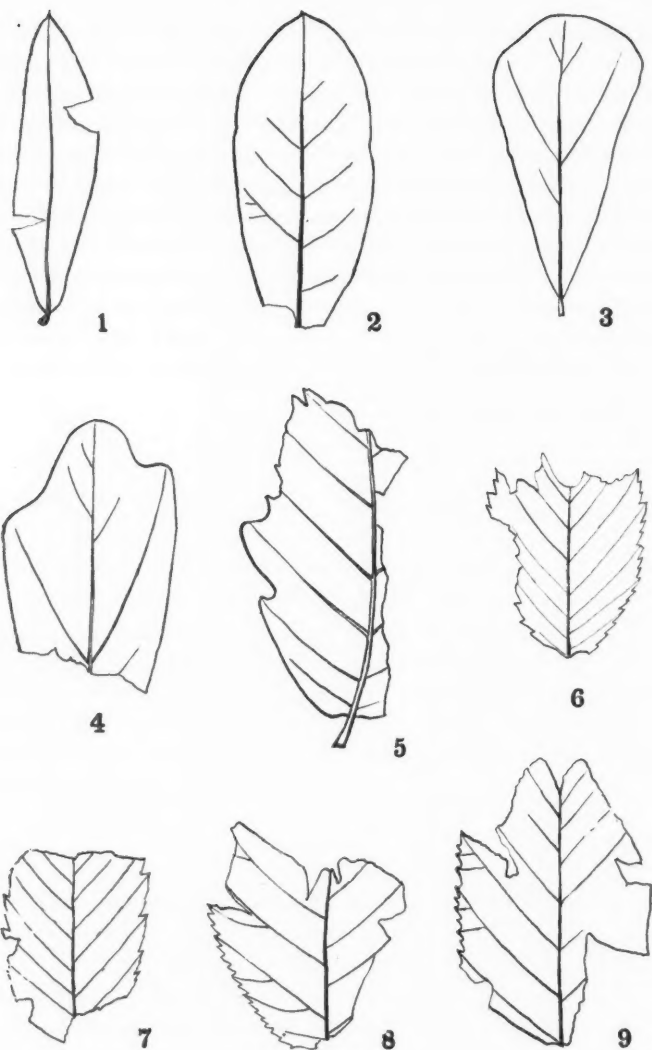


PLATE I

- Fig. 1.—*Quercus phellos* Linné . . . peat. Fig. 6.—*Ulmus alata* Michx. . . . peat.  
 Fig. 2.—*Quercus virginiana* Mill . . . clay. Fig. 7.—*Ulmus alata* Michx. . . . clay.  
 Figs. 3, 4.—*Quercus nigra* Linné . . . peat. Fig. 8.—*Carpinus caroliniana* Walt. peat.  
 Fig. 5.—*Quercus prinus* Linné . . . peat. Fig. 9.—*Carpinus caroliniana* Walt. clay.

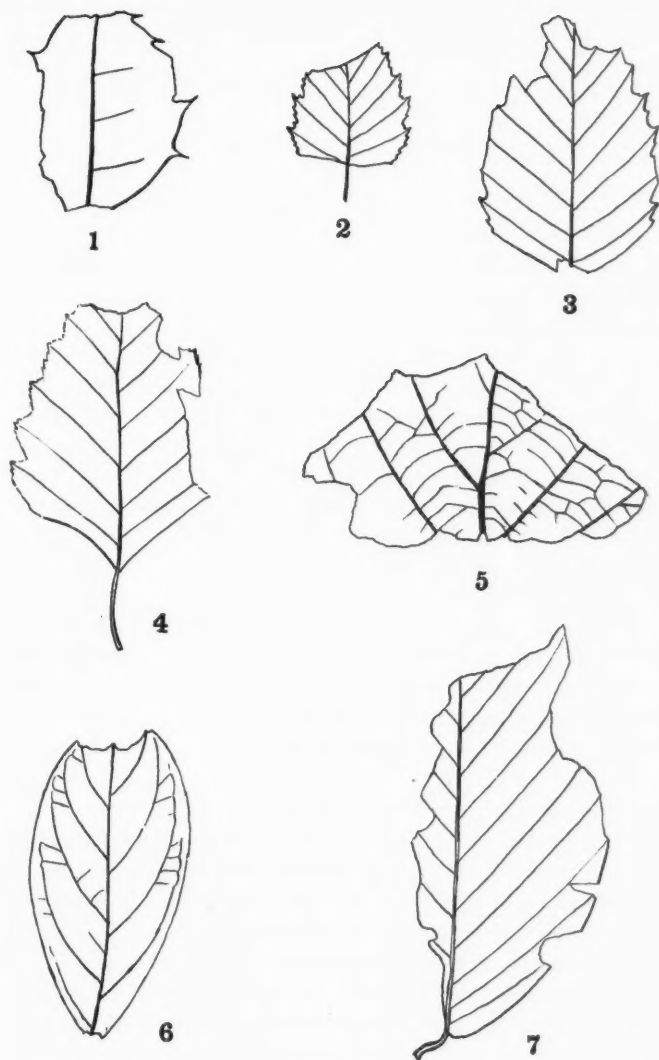


PLATE 2

- Fig. 1.—*Ilex opaca* Ait . . . . . peat.      Fig. 5.—*Platanus occidentalis* Linné . . . . . peat.  
 Figs. 2, 3.—*Betula nigra* Linné . . . . . clay.      Fig. 6.—*Xolisma ligustrina* (Linné)  
 Fig. 4.—*Betula nigra* Linné . . . . . peat.      Britton . . . . . peat.  
 Fig. 7.—*Fagus americana* Sweet . . . . . peat.



## A FURTHER STUDY OF LEAF DEVELOPMENT

FREDERIC T. LEWIS

IN a previous paper (*Amer. Nat.*, 1907, vol. 41, p. 431-441) the writer discussed whether certain forms of adult leaves could be regarded as due to arrested development, so that by comparing the mature leaves of a given plant something of their embryological history could be learned. It was found that where leaflets are formed embryologically from the base toward the apex, as in most pinnate leaves, the terminal leaflet of the mature leaf is often lobed. Where leaflets are formed from the apex toward the base, as in most palmate leaves, the basal leaflets are often lobed. In the rose, in which the leaflets are also formed from the apex toward the base, neither apical nor basal leaflets are lobed, but new leaflets appear near the stipules to which they are often joined. In the previous paper the sumac and honey locust were described as basifugal forms, and the blackberry and rose as basipetal, the latter being of the stipular type. In the following pages it will be shown that the basipetal and basifugal directions of growth may both occur in a single leaf; and that, although one becomes predominant, evidences of the other are apparent. In some cases a single species presents both pinnate and palmate leaves.

The simplest form of compound leaf is three-parted or ternate, and is produced by the lateral lobation of a simple leaf. The stages in this process as seen in the mature leaves of *Clematis virginiana* are shown in Figs. 1a-1d. A ternate leaf may be basipetal in character and pass on to digitate forms with four, five, or more leaflets, or it may be basifugal and produce pinnate leaves. The leaf of *Clematis*, Fig. 1d, exhibits both tendencies. Basipetal growth is manifest in the coarser teeth on the lower margins of the lateral leaflets and in the fact that the part of each lateral leaflet below the midrib is wider than the part above. Basifugal growth is shown in the coarse tooth on either side of the apical leaflet. Although *Clematis virginiana* stops ordinarily at this.

stage, the "very similar" western *Clematis ligusticifolia* goes further, and, by the deepening of the notches in the terminal leaflet, becomes pinnate with five leaflets. Many other species of *Clematis*, including some which are commonly cultivated, have pinnate leaves.

In the poison ivy, *Rhus toxicodendron*, simple leaves are occasionally found, but the typical form is ternate. Many leaves exhibit both basipetal and basifugal features (Fig. 2a), and explain the occurrence of both palmate and pinnate leaves in this species (Figs. 2b and 2c).

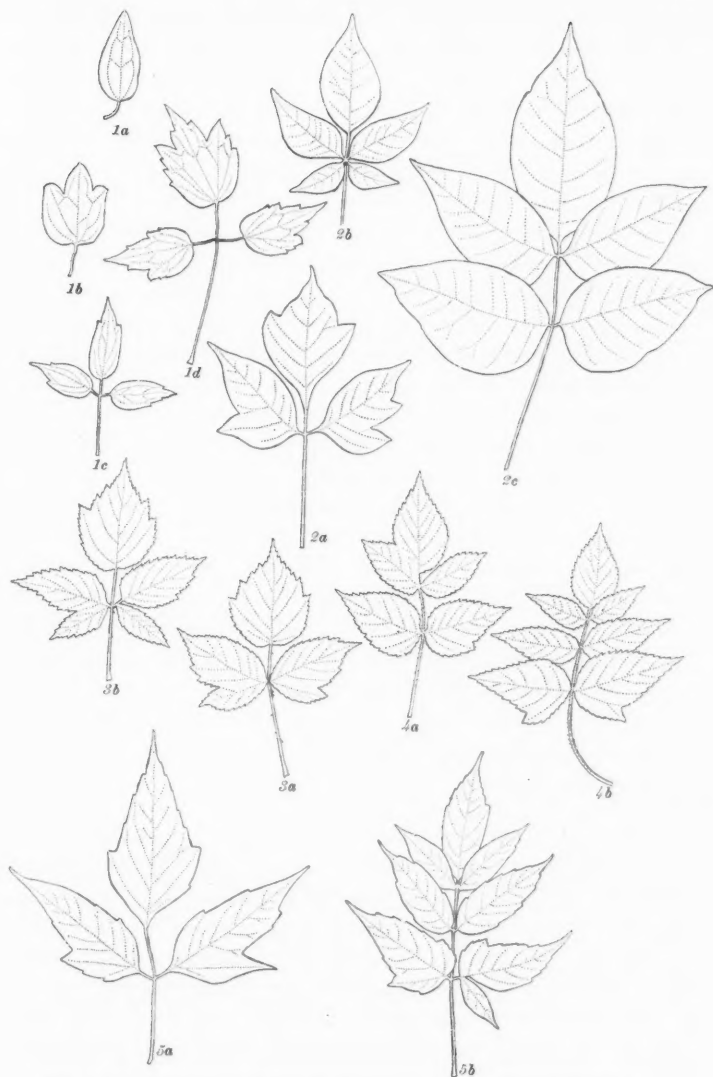
An interesting comparison may be made between the leaves of the black raspberry, *Rubus occidentalis*, and the wild red raspberry, *Rubus strigosus*. In the former, Figs. 3a and 3b, the basipetal tendency predominates, leading to pedate leaves; a basifugal notching of the terminal leaflet is, however, often observed. In the closely related red raspberry basifugal growth leads to pinnate leaves, Figs. 4a and 4b, but basipetal lobation may be seen in the basal leaflets.

The form of leaf shown in Figs. 1d, 2a, 3a, and 4a is seen also in Fig. 5a from *Negundo aceroides*. In the pinnate leaves of this species there may be a basal secondary leaflet, as shown in Fig. 5b. Such evidence of basipetal growth in pinnate leaves is often found. It appears in the long leaves of *Ailanthus glandulosus* (Fig. 6b). In the seedling of this species, ternate leaves with basal notches have been drawn by Jackson,<sup>1</sup> from whose paper Fig. 6a has been taken. Thus it is evident that the basipetal and basifugal directions of growth are present together in a great variety of leaves.

The relation of the basipetal secondary leaflets to twice pinnate leaves is shown in Figs. 7, 8, and 9. In the elder, *Sambucus canadensis*, the basifugal development of primary leaflets is shown in Fig. 7a.<sup>2</sup> The basipetal formation of secondary leaflets appears

<sup>1</sup> Jackson, R. T. Localized stages in development in plants and animals. *Mem. Boston Soc. Nat. Hist.*, 1899, vol. 5, pp. 89-153.

<sup>2</sup> Goebel (*Organographie der Pflanzen*, Jena, 1900, pt. 2, vol. 2, p. 525) classes *Sambucus ebulus* with the basipetal leaves and *Sambucus nigra* with the basifugal. He states,— "Since in nearly related plants the order of development of pinnate leaflets is sometimes basifugal and sometimes basipetal, not much importance can be attached to this distinction."



FIGS. 1a-1d, mature leaves of *Clematis virginiana* L. 2a-2d, *Rhus toxicodendron* L. 3a-3b, *Rubus occidentalis* L. 4a-4b, *Rubus strigosus* Michx. 5a-5b, *Negundo aceroides* Moench. —  $\frac{1}{2}$  natural size, except 1a, 1b, 1c, and 2b which are  $\frac{1}{3}$ .

in Fig. 7b. If the process of compounding proceeds further, a smaller secondary leaflet will be cut off opposite the one on the lower border of the primary leaflet (Fig. 7c). Thus the basal primary leaflet becomes pinnate and develops further in the basifugal manner. This order of leaflet formation is seen not only in the elder, but in *Aralia nudicaulis* (Figs. 8a-8c) and in *Cicuta maculata* (Figs. 9a-9b). It is of widespread occurrence.

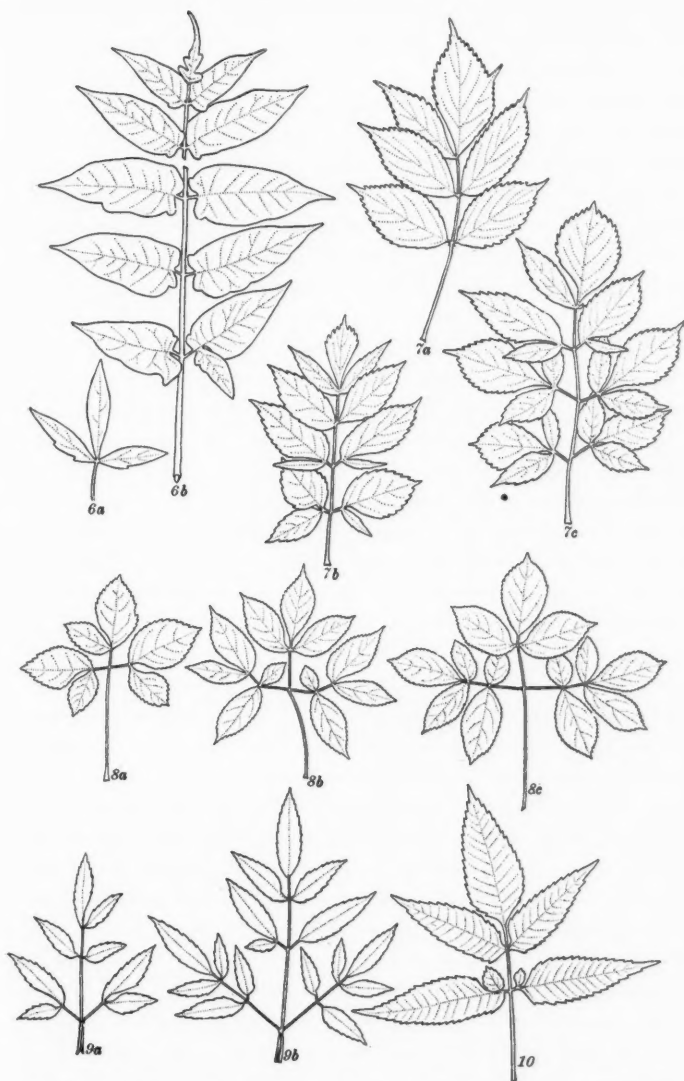
An unusual exception to the basal formation of secondary leaflets is seen in many leaves of *Bidens frondosa* (Fig. 10). In this species the secondary leaflets are usually on the upper margin of the basal leaflets. They may become matched by leaflets on the lower margin, and sometimes the leaflet on the lower side is formed first. Frequently in *Sambucus canadensis* the secondary leaflets first appear on the distal sides of the basal leaflets, as in *Bidens*, but usually they develop on the basal side, both in *Sambucus* and in most of the species examined.

The development of the pinnate leaves of the rose, as described in the previous paper, is so different from that of other pinnate leaves as to require further study. Eichler<sup>1</sup> has classed with the rose, as basipetal in development, the leaves of *Sanguisorba officinalis*, *Poterium sanguisorba*, *Potentilla anserina*, and "probably all potentillas with compound and divided leaves." The basipetal nature of the palmate leaves of *Potentilla canadensis* is obvious. In "Gray's Manual" they are described as "ternate but apparently quinate by the parting of the lateral leaflets." Frequently they develop seven leaflets without lobation of the central leaflet. In *Potentilla fruticosa*, however, the central leaflet shows various degrees of indentation, and if one may judge from mature leaves, basifugal growth occurs. The entire leaf is pinnate. *Potentilla anserina* also shows lobed terminal leaflets.<sup>2</sup> It is possible in these forms that the proximal leaves are added basipetally but they are not connected with the stipules, and lobed proximal leaflets were not observed in the plants examined.

The same is true of agrimony leaves. Basal lobation and fusion with stipules were not observed. Terminal lobation (Fig. 11) was shown in two leaves among four hundred and fifty.

<sup>1</sup> Eichler, A. W. Zur Entwicklungsgeschichte des Blattes. Marburg, 1861, 60 pp.

<sup>2</sup> Goebel agrees with Eichler in considering *Potentilla anserina* as basipetal.



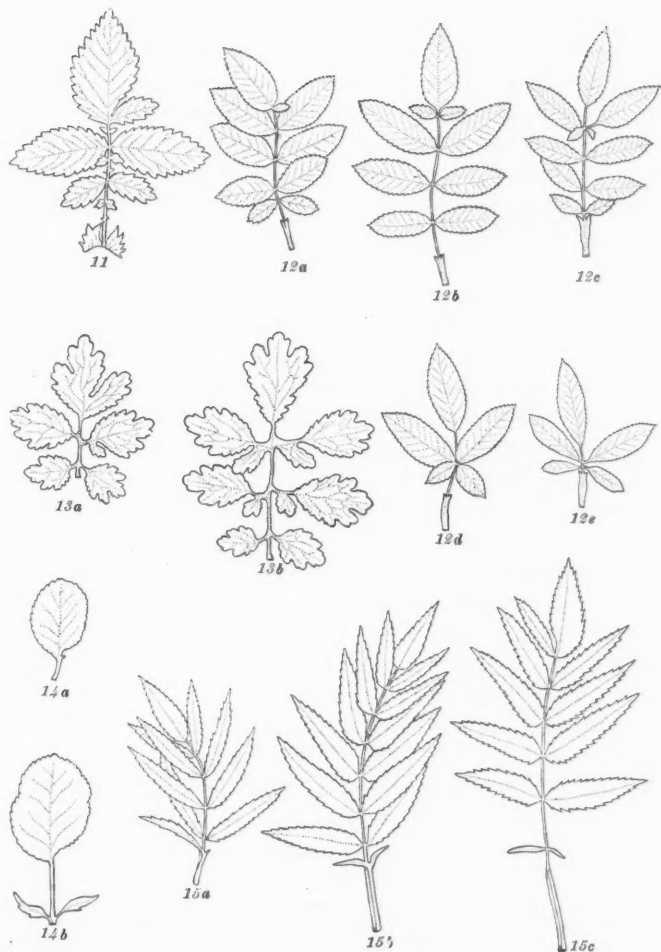
FIGS. 6a-6b, *Ailanthus glandulosus* Desf.; 6a, from a seedling, after Jackson; 6b, the distal and proximal parts of a mature leaf having 13 pairs of leaflets. 7a-7c, *Sambucus canadensis* L. 8a-8c, *Aralia nudicaulis* L. 9a-9b, *Cicuta maculata* L. 10, *Bidens frondosa* L.—6a,  $\times \frac{1}{2}$ ; 6b,  $\times \frac{1}{4}$ ; 9a and 9b,  $\times \frac{1}{2}$ ; the others,  $\times \frac{1}{2}$ .

Twenty-seven hundred leaves of *Rosa lucida* yielded none with a lobed terminal leaflet, but basifugal growth was suggested by the two leaves figured as 12a and 12b. Several leaves with secondary leaflets attached to the distal pair of primary leaflets were observed (Fig. 12c). In *Sambucus*, *Aralia*, and *Cicuta*, the oldest leaflets are the ones which give rise to secondary leaflets, and they are consequently found toward the base of the leaf. Their distal position in the rose may be correlated with basipetal development. In the celandine, however, in which growth seems clearly basifugal, the distal leaflets produce secondary leaflets as in the rose (Figs. 13a and 13b).

Among the twenty-seven hundred rose leaves there were none with the proximal leaflets lobed. One pedate leaf was found (Fig. 12d) together with several forms like that in Fig. 12e. These suggest that leaflets cut off from the basal pair may be carried down the petiole as should occur in a truly basipetal pinnate leaf. However, lobation of the proximal leaflets of a ternate leaf leading to the production of a pinnate leaf has never been found by the writer, and the rose leaves in Figs. 12d and 12e may be explained by the close approximation of the two basal pairs of leaflets.

In the previous paper it was suggested that the first notches in the embryonic rose leaf divided the blade from the stipules, and that the leaflets arose in connection with the latter. The mature apple leaf drawn in Fig. 14a indicates that a notch dividing the blade from the stipule developed on one side only. In small apple leaves the stipules are adherent to the petiole much as in the rose; in larger leaves they are cut off as filiform appendages attached by one end. They may still develop into leaflets as shown in Fig. 14b. In *Sanguisorba* and *Poterium*, which sometimes show a lobed terminal leaflet, there is evidence of stipular basipetal growth. Thus in *Poterium canadense* a single leaflet or a pair of leaflets may be found close to the stipules and separated by a long stretch of petiole from the more distal leaflets. Sometimes the stipules are scarcely to be distinguished from leaflets, to which they are probably giving rise. Such a leaf is figured by Cushman (*Amer. Nat.*, 1903, vol. 37, p. 354) who states that the lowest pair of leaflets has "almost the character of stipules."

In *Sium cicutaefolium*, which has basifugal pinnate leaves, the



FIGS. 11, *Agrimonia eupatoria* L. 12a-12e, *Rosa lucida* Ehrh. 13a-13b, *Chelidonium majus* L. 14a-14b, *Pyrus malus* L. 15a-15c, *Sium cicutaefolium* Gmelin.— 12e, natural size; 12c, 14a and 14b,  $\times \frac{1}{2}$ ; 12d, 15a, 15b, and 15c,  $\times \frac{1}{4}$ ; the others,  $\times \frac{1}{2}$ .

basal leaflets are often joined to the thin sheath-like stipules. In fact the relation of the leaflets to the stipules is strikingly like that in the rose, as shown in Figs. 15a-15c. In the first there is a well developed leaflet proceeding from the stipule on one side, and there is no corresponding opposite leaflet. In the second the stipules are prolonged into small green leaf-like appendages, and in the third the small pair of leaflets above and separate from the stipules suggests a stipular origin. If this is true, leaflets in *Sium* are added from both ends, and the basal pairs of leaflets are not always homologous as stated by Shull.<sup>1</sup>

Shull's study of *Sium* supplies an admirably complete record of the leaf-forms presented by a single species. They are, however, considered from the biometric rather than the embryological point of view. Thus the early leaves are divided arbitrarily into six groups or categories. One of these contains the ternate leaves with basally lobed lateral leaflets and three lobed terminal leaflets, — that is, leaves like those of the poison ivy (Fig. 2a) and Negundo (Fig. 5a). This fundamental class which exhibits symmetrically the basipetal and basifugal directions of growth, is described as simply a special case of variously notched three-parted leaves "which was separated from the others only because it could be so definitely characterized." Although Shull includes only 20% of the first leaves of *Sium* in this category, a large proportion of the forms placed in the remaining five groups are but variations of this type,— the terminal lobes may be suppressed on one or both sides, the basal lobes may be secondarily notched, etc. The study of *Sium* shows that the leaves at first exhibit both basipetal and basifugal tendencies and that the latter becomes predominant.

#### SUMMARY.

The leaves of very diverse species show a common method of leaf development in which the basipetal and basifugal directions of growth are combined. This is shown by the widespread occurrence of the ternate leaf with the three lobed apical leaflet and

<sup>1</sup> Shull, G. H. Stages in the development of *Sium cicutaefolium*. Carnegie Inst. of Washington, Publ. No. 30, 1905. 28 pp.

basally lobed proximal leaflets. This form appears with more or less distinctness in *Clematis virginiana*, *Rhus toxicodendron*, *Rubus occidentalis*, *Rubus strigosus*, *Negundo aceroides*, *Ailanthus glandulosus*, and *Sium cicutaefolium*. By the predominance of the basipetal or the basifugal element, palmate or pinnate leaves are produced respectively. Twice pinnate leaves develop along the same plan; in becoming twice pinnate a basipetal secondary leaflet becomes matched by a smaller leaflet on the distal border and further development of secondary leaflets in basifugal. This is shown in *Sambucus*, *Aralia*, and *Cicuta*, and the exceptional nature of *Bidens* is recorded.

The manner of leaf development in the rose requires further study. The formation of leaflets in connection with stipules occurs in *Poterium*, *Sium*, and the rose, but in *Sium* and to a less extent in *Poterium* they form also from the terminal leaflet. Lobed leaflets in the rose were not found.

Jackson's studies have shown that some Cretaceous leaves are like the simpler stages in the corresponding existing species, notably in the tulip trees. Shull concludes, however, that "no satisfactory inferences can be drawn from ontogenetic leaf-characters regarding the phylogenetic history of the species." He states that there is need of physiological interpretation, and further biometric studies of leaves are being made. In connection with paleontological and biometric studies it is important that the embryology of leaves should be known, not by inference from mature leaves but by reconstructions of the embryonic stages.

The preceding descriptions of adult leaves show that there is a determinate evolution of leaf forms, whereby diverse species tend to produce similar shapes. Plants with simple leaves constantly show tendencies toward compounding. The "obscurely lobed" leaves of *Malva rotundifolia* are occasionally deeply divided, and the notches on the red maple leaf may become clefts extending to the petiole. The persistent production of the similar forms of compound leaves which have been described is evidence in favor of determinate or orthogenetic evolution.



## EARTHWORMS AS PLANTERS OF TREES

E. A. ANDREWS

THAT squirrels aid the forester by burying nuts, some of which may be left to germinate and so start new trees, has long been known; but that common earthworms play a like part in the drama of the woods has not been suspected. The following observations, however, show that the earthworm may be of use in aiding the germination of at least one important kind of tree and raise the question whether they do not do the same for some other trees as well as for many smaller plants.

The earthworm assists in planting by bringing the seeds into close contact with the soil, even burying them. Here, as in the case of the squirrel, the object sought by the animal is not the germination of the seed. The squirrel is following a strong food instinct in hiding away nuts, many of which it will find again and eat; the earthworm is also obeying a very strong instinct, which is, however, only in part a food instinct. This instinct expresses itself in the somewhat mysterious habit the earthworm has of plugging up its burrows.

As is well known, some of our common kinds of earthworms make holes in the ground and inhabit them for long as places of protection from dryness and from various enemies. In the night time, however, these earthworms may leave their burrows more or less completely, to seek on the surface of the ground various objects to be used as food, and to associate with other earthworms. They then seize and eat both live and dead vegetable matter, and soft animal matter when available; and they also drag back to or into their burrows both edible and inedible objects. At times the materials collected at the mouths of earthworms' burrows plug them up most effectively, so as to suggest that the chief purpose of this activity is to close the opening of the burrow after the worm has gone in. Thus one may frequently see tufts of pine needles, of dead brown or of fresh green deciduous leaves, or of other light objects that may have been upon the surface, sticking up here

and there over the ground, each tuft so tightly and completely filling a burrow that one might at first suppose that children at play had deftly thrust leaves into all the earthworms' burrows.

It was this strong instinct to plug up its burrows which Darwin seized upon as a means of enquiry into the mental powers of the earthworm. Scattering triangles of paper over the ground he judged from the way in which these triangles were used by the worm in plugging its burrows that it distinguished between angles of different acuteness and probably exercised something akin to reasoning. In his classic work on the earthworm Darwin does not refer to the possible collection of seeds, though he discusses the plugging instinct at considerable length. He says,—“Worms seize leaves and other objects not only to serve as food, but for plugging up the mouths of their burrows; and this is one of their strongest instincts. Leaves and petioles of many kinds, some flower peduncles, often decayed twigs of trees, bits of paper, feathers, tufts of wool, and horse hairs are dragged into their burrows for this purpose.... They often, or generally, fill in the interstices between the drawn-in leaves with moist, viscid earth ejected from their bodies; and thus the mouths of their burrows are securely plugged.... When worms cannot obtain leaves, petioles, sticks, etc., with which to plug up the mouths of their burrows, they often protect them by little heaps of stones; and such heaps of smooth, rounded pebbles may frequently be seen on gravel walks....” Darwin was inclined to think that one advantage gained by the earthworms in plugging up their burrows lay in the protection gained from cold night air, from animal enemies, and less probably from rain.

Whatever the utility of this instinct, it is carried out with so great a variety of objects, that it was not surprising to find earthworms plugging their burrows with the dry, flat fruits of the maple tree. On May 30th the ground under several large silver maple trees in Druid Hill Park was thickly sprinkled with the yellow key-fruit, or samaras, that had fallen from these trees, and it was quite noticeable that in many places these fruits were gathered together in little heaps. Each collection of seeds contained from twelve to fifty, some lying loose, others more or less buried in the earth. One of the larger heaps when lifted up filled a hand nearly full.

In some places the heaps were not more than a foot apart, but elsewhere they were more sparsely scattered. When any heap was dug up it was found to be a mass of samaras, bound together with earth and some few fibers, probably dead grass.

The ground about some of the collections of maple tree seeds was markedly free from seeds and clean, so that it seemed as if the worms had reached out of their burrows to nearly their full length of eight or nine inches and dragged back all the seeds they could find in a circular area of which their stretched out bodies made the radius. All this was much more evident in the areas close to the tree trunks where there was little or no grass, while far out from the tree trunks, where the grass was thick, the heaps of seeds were smaller and not so evident, both because of the grass and because there was a more uniform distribution of seeds with a less perfect cleaning up of the neighborhood of each heap.

The earthworms' holes were completely closed by the samaras and earth. When about an inch deep of earth and seeds had been removed the open burrow was seen as a clear hole about as big as a pencil. An imaginary section down through a heap of seeds would show a low cone made of seeds imbedded in earth, covered with some dry, free seeds on the surface, the whole rising an inch or more above the normal surface of the ground and of the upper end of the earthworms' burrow.

It was not determined what species of earthworm made the collections of maple seeds. The few small red earthworms found in some cases lying in amongst the seeds and moist earth that plugged the burrows, probably had nothing to do with the making of the burrows or with the collecting of seeds, though they may have profited by the moist vegetable food and other conditions found in these heaps.

The samaras were for the most part buried so that the flat wing was down and the thick part, containing the seed, uppermost; in fact in many cases it was only the wing that was in the ground. However, in some cases the seed was down and the wing uppermost. Apparently the earthworm had as a rule taken hold of the samara by the flat wing and dragged it with this part foremost. While the samaras lying loose upon the ground were all intact and not injured many of those inside the heaps were frayed and frazzled so that the shorter side of the wing often looked like a comb.

Probably the worms had macerated and eaten off the leaf-like part of the samaras but left the seed end uninjured.

In every collection of seeds some three or four, or more, had sprouted, while outside these collections none of the seeds lying over the ground were found to have sprouted. Most of the sprouting seeds showed merely a short radicle and in the many cases in which the seed end of the samara was above ground the radicle was growing down to enter the earth. Some of the seeds that were well buried had advanced farther; in one case the young stem was three inches long and bore a small expanding plumule.

Though so many young trees were thus started by the aid of earthworms in a situation in which the seeds did not sprout at all unless thus brought into connection with the necessary moisture, few of these seedlings made much further progress, as the conditions were too unfavorable. But even after a long dry hot period, on June 27th, some dozens of young trees were found scattered over the bare ground under the more densely shading parts of the mother trees, where they were not destroyed by the lawn mowers as completely as were any that started to grow in the grass. These little trees were three to four inches in height; the cotyledons were shrivelled while two or three pairs of leaves of maple shape were now in evidence. Some of the trees were in groups with remnants of old decayed samaras about them to indicate the former mound of earth, since washed away. The many trees standing isolated were deeply implanted in the ground and probably stood where earthworms' mounds had been. A photograph taken then shows six or seven little trees of different sizes all rising up close together from one old heap of samaras. Even these favored few did not survive the increasingly adverse conditions, for on August first, when the hard dry ground under the parent trees was marked by radiating, branching streaks of brown grass that had died over their old superficial roots, all the seedling trees had disappeared.

The failure of this particular planting, under such conditions, does not, of course, invalidate the contention that in nature the earthworms may play quite an important part in forestry. They probably more than amend, by planting trees, the damage with which they are credited through destroying seedlings in gardens.

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## THE CAUSE OF GYNANDROMORPHISM IN INSECTS

T. H. MORGAN.

IN recent years many cases have been recorded in the group of insects in which parts of the body show the characters of the male and other parts those of the female. Most frequently the separation lies along the middle line of the body, so that one side is like the male and the other like the female. About two years ago I attempted in the case of the bee to correlate this result with the well known frequency of dispermy of the insects' egg.<sup>1</sup> Two spermatozoa having entered, one fuses with the egg nucleus and its products produce the female characters; the other develops alone and gives the characters of the male to the parts of the body it supplies with nuclei, etc.

That the latter assumption is not arbitrary is shown by experiments with the egg of the sea-urchin in which it has been possible to fertilize a non-nucleated piece of the egg with a single spermatozoon. Boveri has attempted to prove that under these conditions the characters of the larvae are paternal, which is in accord with our hypothesis for the bee. The evidence however on which Boveri's conclusion rests has been disputed. More recently Godlewski has succeeded in cross-fertilizing a non-nucleated fragment of the egg of a sea-urchin with the sperm of a crinoid. The characters of the young larvae are said to be maternal, indicating that the protoplasm rather than the nucleus is the controlling factor in determining the characters, but Godlewski's statements apply only to the very earliest stages of development, where according to Driesch's results the maternal influences predominate.

A test of the view that I have suggested should be found for the bee if a gynandromorph should arise in a cross between two species; for, on my hypothesis those parts that develop from the combined nuclei should be female and hybrid in character, while those that come from the single nucleus of the spermatozoon should be male

<sup>1</sup> Morgan, T. H. An Alternative Interpretation of the Origin of Gynandromorphous Insects. *Science*, 1905, vol. 21.

and paternal in character. The most remarkable case of gynandromorphism that has ever been described, namely, that of the Eugster hive, resulted from a cross between two species of bees, but it is impossible to tell from von Siebold's description the specific characters of the male and female parts. A test case is apparently furnished in a recent paper by Toyama<sup>1</sup> "On Some Silk-worm Crosses with Special Reference to Mendel's Law of Heredity." Since Toyama has not attempted to draw any conclusion from the interesting cases that he has found I venture to call attention to their possible interpretation.

A cross was made between two races of silk-worm moths; the female belonged to a European breed having striped caterpillars; the male belonged to the common Japanese breed having plain, *i. e.* not striped, caterpillars. Two of the hybrid caterpillars had the left side of the body striped (maternal) and the right side plain. Applying my hypothesis to this case we see that the striped side is due to the combined nuclei — the striped character carried by the egg dominating the plain character of the sperm-nucleus; the plain side is due to the sperm nucleus alone and is therefore paternal.

It might possibly be objected that the striped race was not pure but produced some plain germ cells, so that the right side is due to this condition; but there is no evidence that the striped race is impure in this respect and the many experiments made by Toyama with this race would have shown the impurity had it existed.<sup>2</sup> Moreover the striped condition of the left side shows that the egg of this individual must have carried striped characters since this character is not carried by the sperm.

Boveri suggested a different interpretation of gynandromorphism. He assumed that the results are due to the single sperm, that enters, fusing with one pole alone of the segmentation spindle derived from the egg nucleus. Toyama's case offers an opportunity to test whether Boveri's or my own hypothesis applies here. For ex-

<sup>1</sup> Toyama, K. Studies on the Hybridology of Insects. I. On Some Silk-worm Crosses, with Special Reference to Mendel's Law of Heredity. *Bull. Col. Agric. Tokyo Imperial University*, 1906, vol. 7.

<sup>2</sup> The striped race was found, however, to be impure in another respect. It may produce a pale form but the occurrence of the pale form has no bearing on our conclusion.

ample, according to Boveri's view the single nucleus (that supplies the male parts in the bee) is derived from the egg which in the present case contains the striped character; the other side is derived from the combined nuclei which should also be striped in the present case since this is the dominant; but the facts are contradictory to the hypothesis. On the other hand the facts are what my hypothesis calls for.

So far I have attempted to consider Toyama's cases without regard to the question of the sex of the right and left halves because while this raises some even more interesting issues, the conclusions are more problematical, since we do not know in the moth the nature of the factors that determine sex. Several possibilities must be considered. If however we are justified in extending the conclusion reached above in regard to the origin of these gynandromorph — a conclusion I repeat, that is reached independently of the question of sex — to the case of the bee, where more is known in regard to sex determination, we shall be led to some far reaching and important considerations concerning sex determination.

The moth that emerged from Toyama's gynandromorph caterpillar had on the left striped half of the abdomen, external female reproductive organs; and on the right plain half, male organs. In my view the right side has come from the single spermatozoon. It has produced the male sex. Two interpretations are here possible. If there exist in the silk-worm moth two kinds of spermatozoa — male and female producers — as shown by Stevens and Wilson for some other insects, the right side may be due to a male-producing (arrhenotokous) spermatozoon; while the opposite female side would be due to a female-producing (thelytokous) spermatozoon having fused with the indifferent (?) egg nucleus. On the other hand the results may be due to a single nucleus alone being capable of forming the male characters only. The evidence, even for the egg is not clear for the moths, for while cases have been described in which only females appear from unfertilized eggs, there are other cases in which both males and females developed. Until we know something of the behavior of the polar bodies in these cases it is unsafe to draw any conclusion in regard to the eggs, and much more so in regard to the spermatozoa.

In the case of the bee these conditions are better understood. It appears as a rule that all unfertilized eggs produce males, and all fertilized eggs produce females. The latter result must be due to all the sperm being female producers, or to only female sperm being capable of entering the egg, or to a quantitative relation, namely, the combined nuclei producing female characters and the single nucleus producing male characters. If we are justified in extending to the bee the conclusion reached above for the moth we can decide amongst these three interpretations. If the gynandromorphous bee is due to one sperm nucleus fusing with the egg nucleus and one (or more) sperm nucleus failing to fuse but developing alone, then the sperm are not female-producing but alone are male-producing. The egg nucleus alone is also male-producing as seen in the development of drones. Combined, however, these two male-producing nuclei give rise to a female-producing nucleus. If this conclusion proves to be correct it throws an interesting light on one of the ways in which sex determination is accomplished.

Equally important is the conclusion to which we are led in regard to the relative influence of the spermatozoon versus that of the egg-protoplasm — a question, as we have seen, on which the experimental embryological evidence is still in doubt. The sperm supplied with egg protoplasm gives rise *in the adult* to paternal characters only, even in those cases like the present one in which the egg carries the dominant characters! If we think of the spermatozoon as introducing a nucleus only, the paternal characters may be attributed to the nucleus; if we think of the spermatozoon as introducing also some cytoplasm — the centrosphere for example — the results might be supposed to be due either to the introduced nucleus, or to the introduced cytoplasm, or to both. Since however the egg also supplies cytoplasm (and that of the dominant kind in the present case) this would offset that of the spermatozoon. It seems therefore that the nucleus is the essential factor. Thus our analysis furnishes a clue as to what part of the sperm carries the factors that determine the characters of the adult organism.

COLUMBIA UNIVERSITY, NEW YORK  
Sept. 15, 1907

## NOTES AND LITERATURE

### GENERAL BIOLOGY

**Mental Development in the Child and the Race.**<sup>1</sup>—"Then there are the biologists—one almost despairs of them! Are there any yet born to follow the two I have named (Spencer and Romanes) in finding mind as interesting as life?" Professor Baldwin has not been compelled to repeat in the new edition of his stimulating book the statement which we have quoted from the preface to his first edition, for, as he remarks, the ten years since it was written have witnessed a remarkable change in the attitude of biologists toward psychology. The truth is that not a few of the leaders in biological science have read Professor Baldwin's book and have found in it excellent reasons for opening their minds to the results of the scientific investigation of consciousness. It is to be hoped that many more of them will read the new edition of "Mental Development" critically and with a view to bringing the author's facts, principles, and theories into relation to the pre-eminently important problems of heredity which now occupy the attention of so many biologists.

Since, on its appearance ten years ago, "Mental Development" received many lengthy review notices it is not fitting that we should fully describe the content of the new edition. The author in revising his book has introduced a number of minor changes, but the work stands essentially as it was originally written. For the benefit of those who may desire a more complete statement of Professor Baldwin's views than can be obtained by a reading of the volume under consideration we may say that three other books are now available: "Social and Ethical Interpretations," "Development and Evolution," and "Thought and Things."

R. M. YERKES.

**Racial Descent in Animals.**<sup>2</sup>—Since the general acceptance of the

<sup>1</sup> Baldwin, James Mark. *Mental Development in the Child and the Race: Methods and Processes*. With seventeen figures and ten tables. Third edition, revised. New York, The Macmillan Company. 1906. Pp. xviii + 477.

<sup>2</sup> Montgomery, T. H., Jr. *The Analysis of Racial Descent in Animals*. Henry Holt and Co., New York, 1906, xxi + 311 pp.

theory of descent with modification, the exact genealogical relationship of animals has been an ever recurring question. In one way or another it seems to have fascinated certain workers. With the superficial, it takes the form of arrangements of living species in what is assumed to be a genealogical sequence without regard to the fact that these animals are of the same generation, so to speak, and not ancestrally related. Speculations of this kind have brought much of this work into disrepute. With the serious-minded, attempts have been made to ascertain the principles by which kinship among animals can be determined, and to this class belongs the volume under consideration.

With much care and erudition Montgomery has sought for a sound basis by which animal relationship can be ascertained. This he has formulated in a series of principles as follows: first, evidence of kinship must be sought in the physiological as well as the morphological relations of animals, for these two provinces are in reality mutually interdependent; secondly, all the factors concerning animal processes must be scrutinized; thirdly, the relative value of the different kinds of evidence must be considered; fourthly, monophyletic origins should be assumed unless the opposite can be proved; fifthly, approximately intermediate connectants between species should be anticipated; sixthly, organic modification is a response on the part of the organism to a change in the environment; seventhly, comparisons between diverse organisms are, at best, of the nature of inexact homologies; and finally, the unit of comparison is the individual during its whole life and not at any arbitrarily chosen stage.

It is noteworthy that two classes of evidence much in vogue in the discussion of questions of this kind are belittled by Montgomery. According to him no special light is thrown by embryology on phylogeny, for the development of the individual does not in his opinion recapitulate the development of the race; and the evidence brought forward by paleontology is too fragmentary to be of any service. While it can frankly be admitted that the eight principles enunciated above are worthy of serious consideration in the determination of phylogenies, it is by no means clear that they are of prime importance as compared with certain others; for, notwithstanding the lengthy argument adduced by Montgomery, ontogeny may still vaguely outline phylogeny. The fact that the appearance of a new character in a species involves a change that must influence the whole life cycle of the animal from the egg to the adult does not necessarily blot out other more ancient characters that may appear only at certain stages

and that may recall an adult state of an early ancestor. Moreover it cannot be denied that the fossil record, meager though it is, is the real record, whereas any scheme evolved in accordance with the eight principles already named must remain, if untested by the fossil record, forever hypothetical. How little we would know of the real characters and genetic relations of the reptiles or of the mammals if we limited ourselves to these principles. But, it might be retorted, that granting what has been said about reptiles and mammals what light does the fossil series give us on the interrelations of such groups as the animal phyla, and to this question it must be admitted that no satisfactory reply can be made. But is it perhaps not well to confess at once complete ignorance of a question which from its very nature can receive only such an answer as will remain forever hypothetical? The reviewer is inclined to believe that it is.

G. H. PARKER.

**Hough and Sedgwick's Physiology.**<sup>1</sup>—The volume under consideration is a reprint of the first half of "The Human Mechanism," by the same authors. The latter has been favorably reviewed in the *Naturalist* for March of this year (p. 194). The "Physiology" is an excellent text-book for high school grades, and since further editions will undoubtedly be called for, it is perhaps desirable to suggest that more attention might profitably be given to anatomy, upon which physiology is to some extent founded. The authors state that "in the present book anatomy has been reduced to its lowest terms and microscopic anatomy or histology has been touched upon only as far as seemed absolutely necessary." Some of the anatomical references which might be improved are as follows. On p. 167, "alveolus" is used for "lobule" of the lung; and "air cell" for "alveolus." The thyreoid gland, a median, bilobed structure, is described as "two small organs which lie in the neck, one on each side of the trachea" (p. 66). The red corpuscles are said to be "biconcave disks" (p. 135) although they are now generally considered to be cup-shaped, with a small proportion of spherical forms; they vary in shape, but the biconcave form is not characteristic of circulating blood. Occasionally an unnecessary term is introduced,— "sarcostyle" is not better than muscle fibril or myofibril, and "synapse" is not, for high school scholars, an improvement upon terminal branches.<sup>1</sup> (Neither sarcostyle

<sup>1</sup> Hough, T. and Sedgwick, W. T. *Elements of Physiology*. Boston, Ginn & Company, 1907. 12mo, 321 pp., illus. \$1.25.

(Schäfer) nor synapse (Foster) are in very wide use at present.) Generally, however, the book shows that the authors had in mind the immature student, as when they state that "the surface area of all the red corpuscles of the blood is 3,000 sq. meters or approximately four times the size of a baseball diamond." On the whole it is a book excellently adapted to its purpose, and in its present form it can be still more widely used.

F. T. LEWIS.

## ZOOLOGY

**The Nervous System of Vertebrates.**<sup>1</sup>—Bell's discovery that the dorsal roots of spinal nerves in vertebrates are sensory and the ventral roots motor in function may be said to be the first step in subdividing the nervous organs of these animals into physiological regions. This process has been very much extended recently especially by certain American neurologists with the result that the nerves and central organs of vertebrates have come to be considered as aggregations of elementary systems of fibers essentially homogeneous from a physiological standpoint. The observations upon which this conception is based are contained for the most part in special papers and have not heretofore been collected and condensed into a single readable account. Such an account has been attempted by Johnston in his text-book on the vertebrate nervous system.

The introductory chapters of this work treat of the morphology, development, and physiology of the nervous system, after which its parts are dealt with, not as in most text-books from the topographical standpoint, but from that of physiological components. Chapters are devoted in sequence to the somatic afferent division as represented by the nervous mechanism concerned with touch, the lateral line organs, and the ear; to the visceral afferent division as represented by the visceral sensory apparatus and the organs of taste; to the somatic motor division controlling the skeletal musculature; and to the visceral afferent division concerned with the visceral musculature, etc. These chapters are followed by others dealing with special centers: the cerebellum, mesencephalon, diencephalon, and cerebral hemispheres.

<sup>1</sup> Johnston, J. B. *The Nervous System of Vertebrates*. P. Blakiston's Son & Co., Philadelphia, 1906, xx + 370 pp., 180 illustrations.

Although this method of subdividing the nervous organs and classifying their parts has many points of advantage over the older topographical method, it possesses as elaborated by Johnston its weaknesses and these are most clearly seen in the way in which certain organs of special senses are dealt with. The eye and its nervous connections are put in the somatic afferent division not because they are concerned with touch or any of the derived senses, but because in certain of the lower vertebrates the spinal nerve terminals are stimulated apparently by light. The olfactory apparatus is classed under the visceral sensory division because it is concerned with the acquisition of food. The weakness of this classification is apparent from the fact that the reasoning by which the author is led to assign the olfactory apparatus to the visceral sensory division, if applied to the optic apparatus, would bring these organs under that head instead of under the somatic sensory. In a similar way the organs of taste ought not to be classed as visceral sensory organs but as a somatic sensory mechanism, for the reason that the cutaneous sensory nerves of the lower vertebrates are stimulated by sour and salt substances much as our organs of taste are. In other words the classification proposed by Johnston and others, though avowedly physiological, will not stand the test of even the most elementary physiological facts. This state of affairs is probably due to the common practice of certain neurologists of assigning physiological significance to a part on the basis of purely morphological considerations and without once endeavoring to ascertain by experiment the real function of the part concerned. A detailed classification based upon such a method as this is bound to be erroneous and as in this movement the classification epitomizes results, a complete change of method must be inaugurated before sound conclusions can be arrived at. Johnston's book, though a praiseworthy effort, is characterized rather by an enthusiasm for a novel system of classification than by an appreciation of the weaknesses of this system.

G. H. PARKER.

**The Sense of Touch in Mammals and Birds.**<sup>1</sup>—The title of this volume is too inclusive, as is stated by its author in the introduction. It is essentially an anatomical account of epidermal markings and the papillae of the corium; other tactile organs are not considered. The first part of the book discusses palms and soles macroscopically.

<sup>1</sup> Kidd, Walter. *The Sense of Touch in Mammals and Birds*. London, Adam and Charles Black, 1907. 176 pp., 164 figs. Also The Macmillan Co., New York. \$2.00.

Eighty-six mammals and eleven birds were examined. Cutaneous *ridges* were found to reach their full development only in primates. The coarse walking pads of the large carnivora consist of *rods*, a feature found also in the marsupial wolf of Tasmania, and to some extent in the eagle. The plantar surface of the other birds studied was merely corrugated, like that in *Ornithorhynchus*, *Echidna* and fourteen other mammals. Scaly palms and soles occurred in nine of the eighty-six mammals; smooth epidermis was found only in *Proteles*, and a complete covering of hair only in the rabbit. The palms and soles of the primates are then described in detail, with numerous figures.

The second part of the book deals with the form and arrangement of the papillae of the corium, and is illustrated from sections magnified generally fifteen or twenty diameters. Since half-tone text-figures will not print well on paper with a rough surface, such as is used in the first part of the book, the publishers have printed pages 81-144 on glazed paper. The volume concludes with a physiological discussion, a summary, and an extensive bibliography.

F. T. LEWIS.

**Observations on the Young of the Red Kangaroo.**—A red kangaroo, *Macropus rufus* (Desm.), was born in the Barnum and Bailey menagerie a short time before I became their zoologist, which was in March, 1904. At that time it was just beginning to put its head out of the pouch. The superintendent insisted that he had known of its presence in the pouch for two months and thought it must have been a month old when he first discovered it. About a month after my arrival the little fellow began coming out. Four months seems rather long for the young to remain in the pouch before beginning to come out, in view of their very rapid growth, but the period cannot be less than two months, and is probably three or even more. A month after beginning to come out, he would still rush back on the slightest provocation, going in head first and turning round, but leaving his tail and long hind legs protruding eighteen or twenty inches. In this position he presented a very comical picture.

The kangaroo, in common with other marsupials, is of a very low order of intelligence, and yet this mother was very solicitous for the safety and welfare of her son. At first she gently objected to his coming out, holding him in the pouch with her fore paws. But his budding curiosity and growing activity could not be suppressed and his excursions into the outer world became more and more frequent. At first she would restrain him with her paws from going to the far

side of the cage, keeping him close to her side. The father was permitted to share the cage, but never made any attempt to harm his offspring. On the other hand, he showed no affection for him. From the very beginning the baby displayed the brick-dust red of the father. As is well known, it is no unusual sight, when a herd of kangaroos is feeding, to see the head of the baby protruding from the mouth of the pouch, nibbling grass. I have seen the young eating in this way in captivity.

W. H. SHEAK.

**A Note of the Prairie-dog Owl which resembles the Rattlesnake's Rattle.**—In the summer of 1904 a party of fossil hunters, with four horses (two under the saddle and two hitched to the wagon), was trailing across Wyoming, at the time following up Bridger Creek, a tributary of Bad Water River. As they were moving along an old fence, under and to either side of which were numerous prairie-dog holes, mostly deserted, suddenly a "rattle" caused all four horses to shy out of the road. The saddle horses were brought back, and their riders searched through the low sage bushes and grass for the rattlesnake to kill it. A second warning followed and a prairie-dog owl rose, flying to a fence post some ten feet away, where it alighted and began a third "rattle," and this time all saw its stretched neck, bulging eyes, open beak and vibrating tongue. The whole appearance of the bird indicated assurance that it would thus frighten off any enemy; and it certainly deceived the four plains-bred horses, as well as the men, all of whom had for weeks been familiar with rattlesnakes, and two of them for years. The writer has often been startled by the rattle of the dry lupine pods, known as "rattle weeds," but horses are not so deceived. However they were clearly frightened by the owl.

The usual note of the burrowing or prairie-dog owl, *Speotyto cunicularia* (Mol), is generally described as a squawk, and is not unlike qua-qua-qua-qua, with variations in the last part. Generally the bird is silent, uttering its note only when startled. The unusual rattle of the individual described was heard repeatedly, for we camped about a mile above the prairie-dog holes, and each succeeding day for over a week some or all of the party passed the spot. The owl never failed to warn with its rattle and the horse or horses, no matter how tired, never failed to shy out of the road,—never having associated the rattle with the owl. After ten days the party moved camp and no more was seen of the owl, but it doubtless kept on rattling and deceiving animals

and men. If it succeeds in teaching the trick to its young, a protective habit of great value will be formed.

F. B. LOOMIS.

**Feathered Game of the Northeast.**<sup>1</sup>—In a volume of 432 pages Walter H. Rich, "a keen sportsman," has written of game birds for the man "whose nature study has been conducted . . . mostly over a gun-barrel." He hopes that the scientific ornithologist as well, may find its pages of interest and profit. There are eighty original, full-page half-tone pictures of the birds, which are unusually life-like and in which color contrasts are well brought out. There are also a few hunting scenes, and one drawing in color presenting a pair of wood ducks. The descriptions of the birds are informal, and the author's joy in killing them is undisguised. He admires the woodcock's "lead-carrying grit," and a typical anecdote concludes,— "So the war went on until a lucky shot tumbled the bird from his perch minus half his head." Flavors of the birds are discussed as follows,— "The Sora Rail is usually introduced to the epicure in the form of a pie, and it is in this stage that it makes its best showing"; of the solitary sandpiper he says,— "I think he makes a good impression when, after being skinned, wrapped in a thin piece of fat pork and enclosed in a big potato, he has been well baked." The spruce grouse is "a pretty fowl for a dining room 'bird piece.'" The shooting of whistlers is enthusiastically described. These ducks are now protected within Boston's limits and during the winter they give pleasure to hundreds of people who cross the Charles River daily. Their former destruction, as seen by the genial Autocrat, led him almost to lose his temper, for he wrote,—

He knows you! "sportsmen" from suburban alleys,  
Stretched under seaweed in the treacherous punt;  
Knows every lazy, shiftless lout that sallies  
Forth to waste powder — as *he* says, to "hunt."

In presenting this book the publishers announce that it contains a "timely plea for moderation in seeking game." Brother sportsmen are asked to paste in their hats the motto "Don't forget to leave enough for seed." The author says that "the Whistlers seem to be holding their own in the struggle for existence — a thing which can be said of few of the duck family" and that "indeed it is a matter for wonder

<sup>1</sup> Rich, W. H. *Feathered Game of the Northeast*. New York, Thomas G. Crowell & Co., 1907. 8vo, 16 + 432 p., illus. \$3.00.

that the shore-birds were not exterminated long ago." He would stop spring shooting and close our markets to the sale of game. We wish that the 'great brotherhood of sportsmen' would agree to this. Their attempt to pose as 'lovers of bird life,' as ornithologists, or as 'Roosevelt-like' is unsuccessful; and if our author really desires to "work loyally in an effort to save our wild life from the extermination which threatens," will he continue to destroy it?

F. T. LEWIS.

**Game Laws for 1907.**— *Farmers' Bulletin 308* of the U. S. Dept. of Agriculture presents a summary of the game laws of the United States and Canadian Provinces. In the number of bills introduced and in the general demand for change of some sort the record of 1907 is second to that of no previous year, although the number of bills actually passed was equaled by the legislation of 1905. Most of the changes were made to secure greater protection. In several states the seasons were closed entirely for certain kinds of game. On the other hand in many places certain restrictions were removed. The legislation is said to be in a transition stage; settled policies have not been determined but various compromises are made between the sportsmen, the ornithologists' unions, and the majority of people with whom such legislation is by no means an issue. Thus these laws are arbitrary, complex, and difficult of enforcement. Hunting is prohibited in some Maryland counties on election day; water-fowl are protected on Mondays in Ohio. A Maine license which requires \$5.00 ordinarily for the shipment of a moose, etc., permits shipment to a hospital. Alaska allows the sportsman 25 shore birds a day, whereas Maine permits 15 ducks and 70 sandpipers. Such whimsical laws cannot be permanent, and the study of the situation now being conducted should lead to their improvement. Many measures, last year, were allowed to fail rather than pass in an unsatisfactory form.

F. T. LEWIS.

**Notes on the Structure of Insects.**— *The Ovaries of the Hemiptera.*— In a recent review the writer referred to the two opposing views regarding the development of the sex-cells in the ovaries of insects. As is well known, each ovary consists of a variable number of egg-tubes opening into the oviduct. Each tube is divided into three zones: 1st, the *terminal filament* which, uniting with those from neighboring tubes, forms the suspensorium of the organ; 2nd, the *terminal chamber* and, 3rd, the *germarium* or chambered egg-tube.

According to the more generally accepted view the terminal chamber contains the undifferentiated elements from which are derived not only the eggs but the nutritive cells and the cells of the follicular epithelium which surrounds the developing eggs. Korschelt, who is widely quoted, formerly believed that these elements might be traced back still further to indifferent elements of the terminal filament.

Sharply opposed is the view that the sex-cell is *sui generis*, in origin entirely distinct from the surrounding epithelium. This interpretation has been gaining ground but is opposed by Marshall's recent results.

In view of the conflicting conclusions of previous investigators the recent work of Köhler<sup>1</sup> is of much interest. The fact that the work was done under Professor Korschelt's supervision adds especial weight to the author's conclusions.

The contradictory results obtained by previous workers are due mainly to the use of mature specimens, and to poor technique (staining, fixation, or to thickness of sections). Köhler has studied sixteen species of Hemiptera, of most of which he had immature as well as mature stages. Of three species he had a series of the nymphal stages. Fixation was by means of Hermann's or Zenker's fluids, as alcohol or the much-used corrosive sublimate were wholly unreliable.

It was found that the cells of the peritoneal epithelium, the terminal filament, the epithelium of the germarium and of the follicles, are of common origin. These somatic cells are perfectly distinct from the sex-cells and the nutritive cells which are derived from the latter. The germarium is filled exclusively by the germ cells and is always sharply set off from the terminal filament, usually by a distinct membrane. There are no "free nuclei" present.

Köhler's investigation was not confined to the question of the origin of the cells but included a thorough study of the histological structure of the ovaries, and an especial consideration of cell-division. He found that cell-division takes place in the peritoneal epithelium, terminal filament, egg-tube, and germarium and is always by mitosis. On the other hand the so-called amitotic division occurring in the follicular epithelium is confined to the nucleus and never leads to cell-division. However, the tissue in which it occurs is not senile, but living, and capable of growth and activity. Only after the nuclear divisions have occurred begins the cell activity (secretion of egg-chorion)

<sup>1</sup> Köhler, A. Untersuchungen über das Ovarium der Hemipteren. Zeitschr. w. Zool. 1907, lxxxvii, pp. 337-381, pls. 19-20.

which leads to a wearing out of the tissues. Thus the so-called amitosis is not concerned with cell-increase but leads to increase in surface area of the nucleus, the center of cell-activity.

*The origin of the adipose tissue of the adult fly.*— In most insects the larval adipose tissue persists in the imago, presenting at most slight modifications. In the higher Diptera, however, and especially in the Muscidae, it has been found that the larval fat-tissue disappears completely and is replaced in the adult by a new tissue. This Berlese thought to be derived from the nuclei of larval muscles, while Henneguy regarded it as made up of metamorphosed leucocytes.

Perez,<sup>1</sup> '07, describes a condition much more in harmony with what is known concerning the origin of other adult organs and tissues. According to this investigator the fatty tissue of the adult originates from subhypodermal groups of small, compact, mesenchymatous cells which, like all young cells, stain readily in haematoxylin. These groups are thus the homologues of the imaginal disks.

*The influence of nutrition on reproduction in a spider.*— Lecaillon,<sup>1</sup> '07, finds that the conditions of nutrition strikingly influence egg production in a common spider, *Agelena labyrinthica*. Ordinarily this species constructs a single cocoon, containing from 50–100 eggs. Occasionally double cocoons are to be found, one capsule containing a much smaller number of eggs. By overfeeding, Lecaillon obtained from one female five cocoons in as many weeks. Four of these contained respectively 78, 38, 14, and 5 eggs while the fifth cocoon was small, irregular and empty.

W. A. RILEY.

**Notes.**— The so-called double heart of the mollusk *Arca* has been made the subject of special investigation by A. Theiler (*Jena. Zeitschr. f. Naturwiss.*, Bd. 42, pp. 115–142, Taf. 9–10). The author points out that it is only proper to speak of a double heart where each ventricle has a separate aorta and acts independently of its fellow. Such a condition occurs in *Arca noae*, *A. barbata*, *A. tetragona*, and *A. lactea*. In *A. lactea*, however, there is a common pericardium for both ventricles

<sup>1</sup> Perez, Ch. Origine du tissu adipeux imaginal chez les Muscides. C. R. Soc. Biol. 1907, lxxiii, pp. 137–139.

<sup>1</sup> Lecaillon, A. Influence de la nutrition sur la reproduction d'*Agelena labyrinthica* Cl. C. R. Soc. Biol. 1907, lxii, pp. 334–337.

and in *A. scapha*, according to Ménégaux, there is not only a common pericardium but the two ventricles are represented by one. Thus in different species of *Arca* there occurs all transitions from a single to a double heart.

After an extended consideration of the musculature of the gorilla in comparison with that of man and the lower apes, Dr. A. Sommer (*Jena. Zeitschr. f. Naturwiss.*, Bd. 42, pp. 181-308, Taf. 25-28, 1906) concludes, contrary to the opinion of Huxley, that the gorilla in this part of its structure is more closely related to the lower apes than to man. P.

*Two large frogs from South Kamerun, West Africa.*—The University Museum, University of Michigan, has recently received, in a very interesting collection made by Mr. George Schwab from the vicinity of Efulen, Kribi, Kamerun, West Africa, a specimen each of the Giant Frog, *Rana goliath* Boulenger, and the Hairy Frog, *Trichobatrachus robustus* Boulenger. Both of these specimens agree closely with the descriptions recently published by Mr. Boulenger (*T. robustus* Proc. Zool. Soc. Lond., May 8, 1900, 443; *R. goliath*, Ann. & Mag. of Nat. Hist., XVII, 317-318, and Proc. Zool. Soc. Lond., I, 179). *R. goliath* enjoys the distinction of being the largest frog known, and the above mentioned specimen only slightly exceeds in size the one described by Mr. Boulenger. From snout to vent it measures 300 mm., but Mr. Schwab, the collector, states that *it is only partly grown*. He writes of its habits as follows: "This frog lives only in rivers, about the rocky shores of deep pools. On the slightest provocation it dives away, making it difficult to secure specimens."

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From September 1 to October 1, regular exchanges not included  
The year of publication when not otherwise noted, is 1907

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